

Dec. 21, 1943.

C. P. DISNEY ET AL

2,337,378

METHOD OF MAKING PIERS

Filed March 17, 1943

2 Sheets-Sheet 1

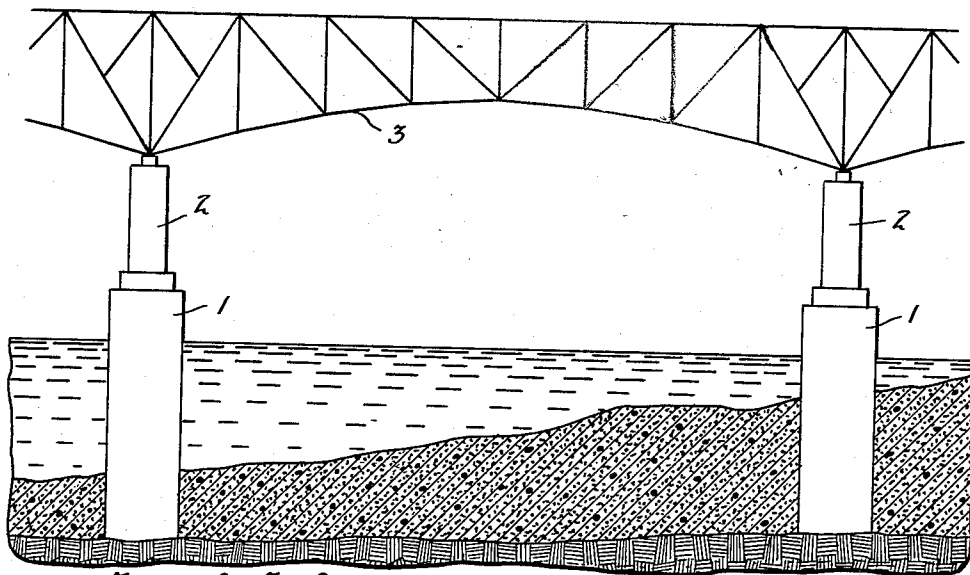


Fig. 1

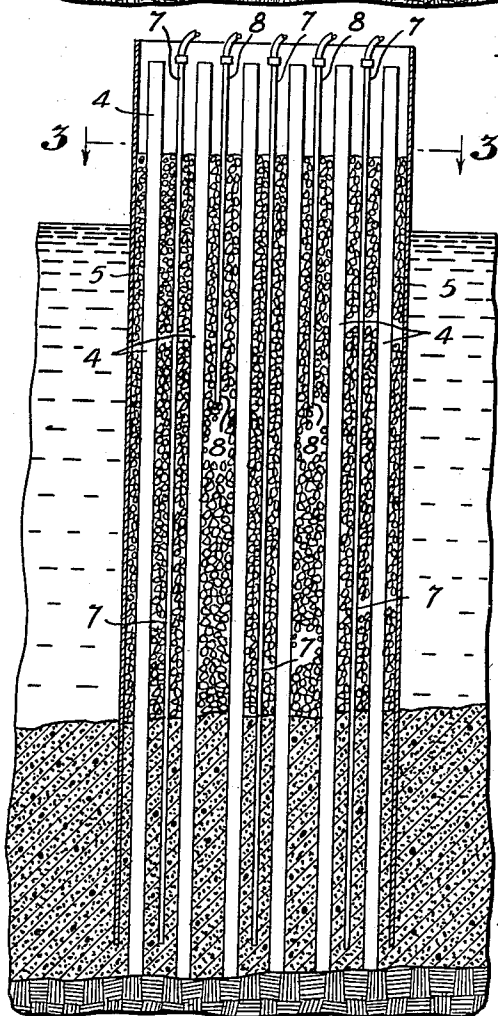


Fig. 2

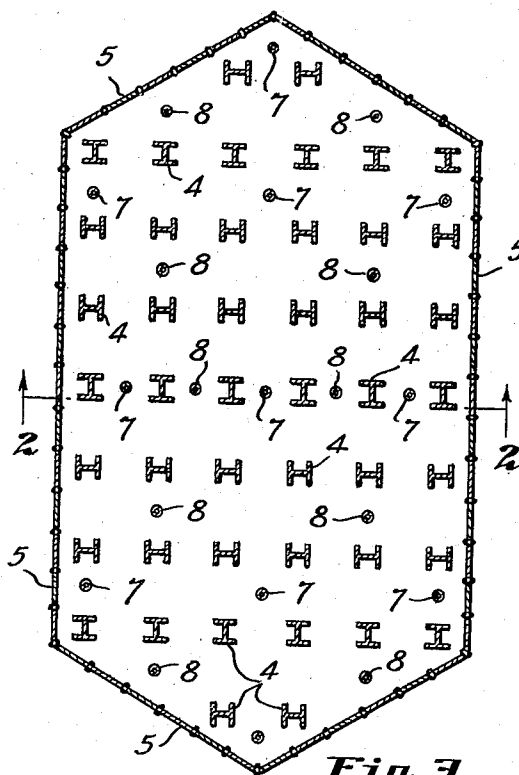


Fig. 3

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2 Sheets-Sheet 2

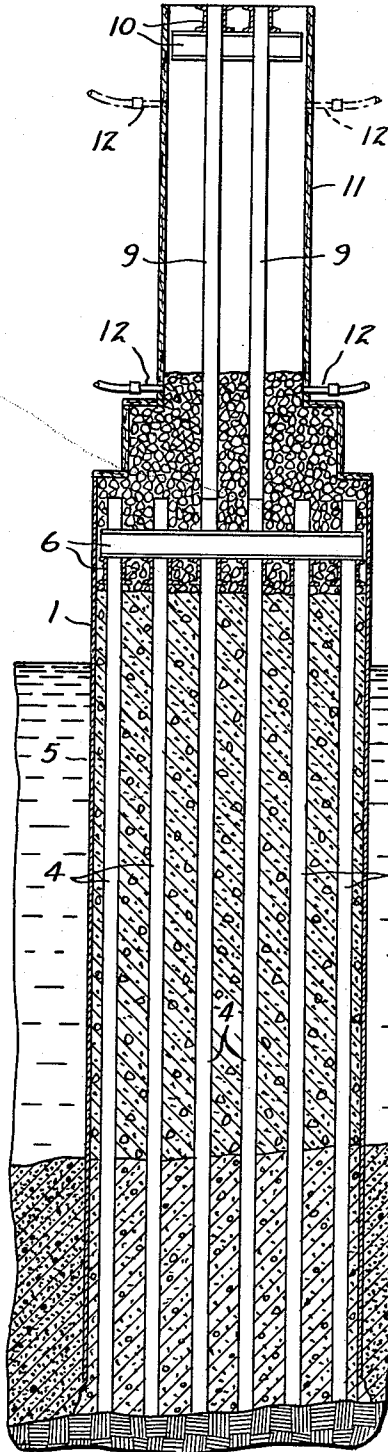


Fig. 4

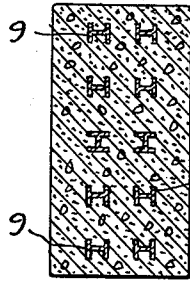


Fig. 6

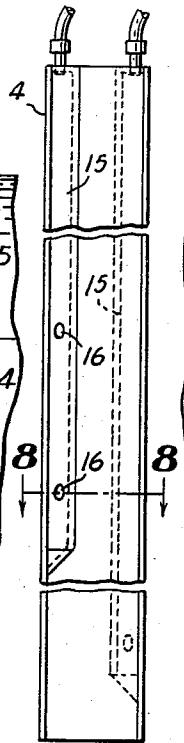


Fig. 7

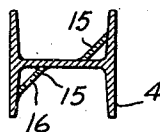


Fig. 8

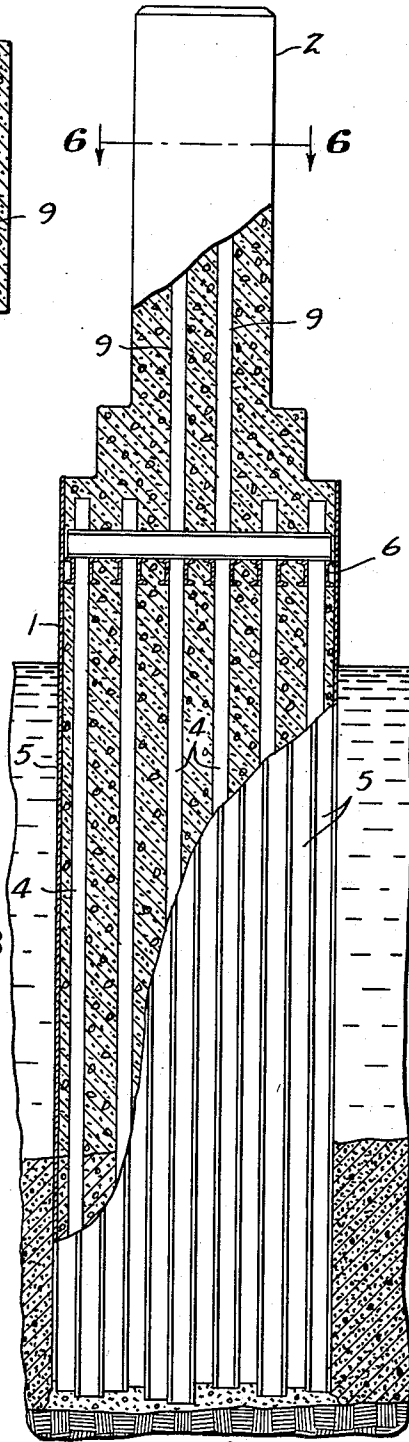


Fig. 5

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METHOD OF MAKING PIERS

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Application March 17, 1943, Serial No. 479,458

12 Claims. (Cl. 61—52)

This invention relates to a method of building concrete piers for bridges or the like with their bases extending from above the water line into the ground to a firm support such as bed rock.

It has heretofore been the usual practice in building bridges over wide and deep bodies of water to support the bridge upon massive masonry piers. The building of the bases of such piers under water by the use of pneumatic caissons or the like is enormously expensive and the expense increases very rapidly with an increase in the depth to which the pier must go below the water level. Because of the enormous expense in building such piers with deep foundations, it is frequently necessary to provide very long spans in the bridges. The spans also become much more expensive as their length is increased. The design of conventional bridges must, therefore, be balanced between the cost of the piers and the cost of the necessary connecting spans.

Pneumatic caissons, besides being extremely expensive, take a very long time to build and are extremely dangerous to the men, because of the high working pressure.

An object of the present invention is to provide a low cost method of building piers in deep or shallow water, thereby enabling one to space the piers relatively closer together than heretofore and thereby dispensing with the need for long span bridges.

An important advantage of the present invention is the elimination of caissons or other expensive apparatus which is required when it is necessary to provide for workmen below the surface of the water. The method of the present invention is performed entirely by means of apparatus above the water level and greatly lessens the time required for the building of piers.

With the above and other objects in view, the invention may be said to comprise the method as illustrated in the accompanying drawings hereinafter described and particularly set forth in the appended claims together with such variations and modifications thereof as will be apparent to one skilled in the art to which the invention pertains. Reference should be had to the accompanying drawings forming a part of this specification in which:

Figure 1 is a side elevation showing a portion of a bridge supported by piers built by the method of the present invention;

Fig. 2 is a vertical section through the base portion of a pier in the course of construction by the method of the present invention;

Fig. 3 is a section taken on the line indicated at 3—3 in Fig. 2;

Fig. 4 is a vertical section through the pier showing the base portion completed and the top pillar in the course of construction;

Fig. 5 is a side elevation of the completed pier with parts broken away to show a portion of the base and of the pillar in section; and

Fig. 6 is a section taken on the line indicated at 6—6 in Fig. 5.

Fig. 7 is an elevational view of a portion of a pile having a conduit formed in a corner thereof.

Fig. 8 is a section on line 8—8 of Fig. 7.

In the present invention reinforcing elements, such as steel piles and a surrounding form are disposed above the rock or solid foundation upon which the pier is to be carried. The piles are ordinarily driven through the ground material overlying such foundation which may be dry or submerged in shallow or deep water. The form is then filled with suitable aggregate which is solidified by pumping a solidifiable, readily flowable, cementitious material therein, without the necessity of removing the water from the enclosed reinforcement. By this method the desired number of piers can be erected and the spans made the most economical length.

In the present method, since the water does not have to be removed from the enclosing form surrounding the reinforcing elements, the form is more in the nature of a retainer for the aggregate and cementitious product and does not have to be of a strength to withstand enormous pressures, such as are attained in deep water.

As shown in the accompanying drawings, the pier constructed by the method of the present invention is a concrete pier having a base 1 which extends into the ground and above the water level. The base 1 may have a pillar 2 extending upwardly therefrom to provide a support for the bridge sections 3. It is to be understood, however, that the pillar 2 is not essential since the bridge may be supported by arches, truss structures, or the like, having abutments mounted directly on bases 1 if desired.

The initial step of the process consists in driving steel piles 4 into the ground until their lower ends are engaged with a firm supporting strata or foundation such as bed rock. The piles 4, which are preferably conventional structural shapes, may be arranged in the desired patterns and spacings throughout the area to be occupied by the base 1 of the pier. In the drawings the piles 4 are shown of conventional H section.

After the piles 4 have been driven into place,

an enclosing wall 5 is formed which extends from above the surface of the water into the ground around the steel piles 4. The enclosing wall 5 may be constructed in any suitable manner of wood or metal, but is preferably formed with interlocking steel sheet piling. The sheet piling may be driven to the same depth as the piles 4 but frequently it is desirable to drive the sheet piling to a depth somewhat less than the piles 4, for a purpose hereinafter described. After the piles 4 have been driven into the ground, the upper ends thereof are preferably connected by means of suitable steel grillage. In the drawings this comprises tie bars 6 which are disposed in crossing relation to provide a stiffening grill work adjacent the upper ends of the piles. The bars 6 may be of any desired conventional structural sections, as for example rolled channel beams, which may be secured to the steel piles by any suitable means such as welding or riveting.

If there is a substantial quantity of silt or other undesirable material on the supporting foundation or intermingled with the natural gravel or stone enclosed by the sheet piling, this material is preferably removed from the interior of the enclosure by jetting or washing or by other suitable means. In some instances it may be convenient to wash the silt out by jets of air or water directed against the silt around the piles 4 before all the sheet piling 5 is driven into place.

If the ground below the water is of such a nature that after washing, pipes can be readily driven therein, a series of pipes 7 may be driven at spaced points throughout the interior of the enclosure and a series of shorter pipes 8 are supported adjacent the top of the piles with their lower ends between the ground and the surface of the water. The enclosure is then filled with suitable coarse aggregate.

In cases where it is difficult or undesirable to drive the grout-carrying pipes through the ground underneath the water, conduits may be carried by the steel piling 4. As shown in Fig. 7, a flat plate 15 may be disposed over a corner of the pile and welded thereto along its edges, thereby producing an enclosed conduit, and the plate 15 may be provided with one or more suitable openings 16 at the desired depth for the egress of grout material into the interior of the pier to be filled.

A special grout of high fluidity is then forced under high pressure through the pipes 7, or conduits, into the ground around the piles 4 and this grout is intruded into the aggregate, gravel, or other porous strata enclosed by the sheet piling. When hardened, this provides a very firm foundation for the pier. The grout, forced under pressure through the pipes 7, readily flows through the ground surrounding the piles within the enclosure so that a solid and massive foundation below the ground level is provided. In cases where it is desired to have the region around the base of the pier solidified the sheet piling may be left above the bottom of the piling, so that the grout or flowable, solidifiable composition will flow beneath the sheet piling and fill the voids and pores of the adjacent region thus in effect enlarging the base portion of the pier. Additional grout may be forced through the pipes 8 into the mass of aggregate to displace the water in the voids and to solidify the aggregate to envelope the piles 4 in a mass of strong concrete.

The grout employed for solidification of the earth strata in which the piles are embedded is

a composition of high fluidity containing, in addition to Portland cement, a colloidal gel retarding agent and a lubricating and plasticizing agent, the composition being not readily miscible with water and capable of displacing water when forced under pressure into the voids and crevices of the earth strata. A composition such as that disclosed in the patent to Wertz 2,254,252 September 2, 1941, may be used. The composition may contain, in addition to the ingredients set forth in the above patent, some calcium chloride, in the amount of about .5% to 3.5% on the weight of the cement, and/or a small amount of aluminum powder, if desired, such as .001% to .05% on the weight of the cement.

The grout employed for filling the voids in the body of aggregate above the ground may be similar to that employed for solidifying the earth around the piles. When filling voids in coarse aggregate and the like, a substantial proportion of sand may be included in the mix.

In case that it is desired to provide an extension above the base 1, such as the pillar 2, extensions 9 may be attached to the upper ends of certain of the steel piles 4, preferably by welding. The upper ends of the extensions 9 may be connected by crossing tie bars 10 similar to the tie bars 6. After the extensions 9 have been attached to the desired group of piles 4, a form 11 is built around the extensions and this form may be filled with concrete to form a pillar around the extensions 9. The form 11 is preferably provided with a number of pipes 12 through which grout may be forced under pressure into a body of aggregate first filled into the form.

It will be seen that piers constructed as above set forth will, in the majority of cases, eliminate the need for long span bridges over deep water. Piers combining the use of steel piling, such as H piling, and concrete, and constructed by solidifying Prepak aggregate with a flowable composition as above described, will solve practically every water and foundation problem and make unnecessary the intricate and expensive pneumatic caisson work that has had to be used in the past, and that has been the basic reason for employing long spans over deep water. Improvements and economies obtained with the present invention are discussed in an article appearing on page 17 of the Canadian publication "Roads and Bridges" for February, 1943, which is published in Toronto, Ontario.

The principles of the present invention may be utilized in various ways, it being understood that the procedure illustrated in the drawings and described above are given merely for purposes of explanation and illustration without intending to limit the scope of the claims to the specific details disclosed.

What we claim is:

1. The method of constructing a pier which comprises driving a group of spaced steel piles into the ground to a firm supporting strata, enclosing the spaced piles with a wall extending from above the water level to the ground, filling the enclosure with aggregate, and injecting grout under pressure into the body of aggregate to replace water in the voids of the body of aggregate with grout.

2. The method of constructing a pier which comprises driving a group of spaced steel piles into the ground to a firm supporting strata, enclosing the spaced piles with a wall extending from above the water level into the ground, removing silt from the interior of the enclosure,

filling the enclosure with aggregate, and replacing water in the voids of the body of aggregate with grout.

3. The method of constructing a pier which comprises driving a group of spaced steel piles into the ground to a firm supporting strata, enclosing the spaced piles with a wall extending from above the water level into the ground, removing silt from the interior of the enclosure, filling the enclosure with aggregate, replacing water in the voids of the body of aggregate with grout, attaching extensions to the upper ends of certain of said piles, building a form about the extensions, and filling the form with concrete.

4. The method of constructing a pier which comprises driving a group of spaced steel piles into the ground, enclosing the group of piles with a wall extending into the ground, intruding grout under high pressure into the ground around the piles, and filling the enclosure with concrete.

5. The method of constructing a pier which comprises driving a group of spaced steel piles into the ground, enclosing the group of piles with a wall extending into the ground, intruding grout under high pressure into the ground around the piles, filling the enclosure with aggregate, and filling the voids of the aggregate with grout.

6. The method of constructing a pier which consists in driving a group of spaced steel piles into the ground at the bottom of a body of water, enclosing said group of piles to above the water level with a wall extending into the ground around said group of piles, intruding grout under high pressure into the ground around the piles, and filling the enclosure with concrete.

7. The method of constructing a pier which consists in driving a group of spaced steel piles into the ground at the bottom of a body of water, enclosing said group of piles to above the water level with a wall extending into the ground around said group of piles, filling the enclosure with aggregate, intruding grout under high pressure into the ground around the piles, and forcing grout into the voids of the body of aggregate.

8. The method of constructing a pier which consists in driving a group of spaced steel piles into the ground at the bottom of a body of water, enclosing said group of piles to above the water level with a wall extending into the ground around said group of piles, filling the enclosure with aggregate, intruding grout under high pressure into the ground around the piles, forcing grout into the voids of the body of aggregate,

splicing extension to the upper ends of certain of said piles, and enclosing the extensions of the piles in a pillar of concrete.

9. The method of constructing a pier which consists in driving a group of spaced steel piles into the ground at the bottom of a body of water, enclosing said group of piles to above the water level with a wall extending into the ground around said group of piles, removing silt from within the enclosure, intruding grout under high pressure into the ground around the piles, and displacing water within the enclosure with concrete.

10. The method of constructing a pier which consists in driving a group of spaced steel piles into the ground at the bottom of a body of water, enclosing said group of piles to above the water level with a wall extending into the ground around said group of piles, removing silt from within the enclosure, intruding grout under high pressure into the ground around the piles, displacing water within the enclosure with aggregate, and displacing water in the voids of the body of aggregate with grout.

11. The method of constructing a pier which consists in driving a group of spaced steel piles into the ground at the bottom of a body of water, enclosing said group of piles to above the water level with a wall extending into the ground around said group of piles, removing silt from within the enclosure, intruding grout under high pressure into the ground around the piles, displacing water within the enclosure with aggregate, displacing water in the voids of the body of aggregate with grout, splicing extensions to certain of said piles, building a form around the extensions, filling the form with aggregate, and forcing grout under pressure into the voids of the body of aggregate within the form.

12. The method of constructing a pier which consists in driving a group of spaced steel piles into the ground at the bottom of a body of water, enclosing said group of piles to above the water level with a wall extending into the ground around said group of piles, tying the upper ends of the piles with a metal grillwork adjacent the top of the enclosure, embedding the spaced piles and grillwork in a body of aggregate filling the enclosure, intruding grout under heavy pressure into the ground around the piles, and filling the voids of the body of aggregate with grout.

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